Critique of
Austin Capital Metro Report
"Technical Report 1. –Congestion Management Benefits for Alternative Alignments of Light Rail in Austin Texas",
HLB Inc. (No Date)

Downloaded from http://www.capmetro.austin.tx.us/future/HLB%201.htm,
April 25, 2000

Jack Mallinckrodt
AJM Engineering
May 7, 2000

As explained in the report

> "The methodology employs the Mogridge-Lewis Convergence Hypothesis to measure the savings in network delay brought about by the transit and its equilibrating effect on the level of service in the corridor. The MLC hypothesis predicts that, in congested urban corridors the time it takes to complete a journey door-to-door tends to be the same across different modes of transportation"

The Mogridge Hypothesis

Here is the first problem. The Mogridge Hypothesis is only a hypothesis, and a highly speculative and controversial one at that. As far as I have been able to determine, Mogridge put it forth as a theoretical hypothesis. As such it is a vast extension of the valid and many times confirmed Wardrop principle that alternative *road* routes used by a significant number of travelers to get from point A to Point B will tend to have equal trip-times. This occurs between alternative roads because: 1) *since there are (generally) no other significant factors in the choice of road*, most drivers will choose the least time route and 2) *as more drivers choose a faster road, it congests and slows down toward equality*. Neither of these conditions is satisfied in the road vs. rail choice. There is no valid theoretical reason to expect the Wardrop principle to apply between diverse modes such as roads and rail.

Empirical evidence is also almost completely lacking. The only plausibility argument offered for it in the subject report is a list of eight instances of measurements on routes paralleling rail lines in large cities that tend to show similar trip-times. This appears to be the best if not only empirical evidence. Certainly, unless there are vast differences between the average speeds of road and rail, one would expect to be able to find *some* cases of accidental similarity among the tens of thousands of such parallel routes in the US. Eight selected instances of near agreement prove nothing at all.

Furthermore, the instances given are not representative of the Austin system(s) or any light rail system for that matter. All these instances are of heavy rail in large cities: New York, Chicago, Philadelphia, San Francisco, etc. Heavy rail generally has average daily traffic about six times that of light rail and is as much as twice as fast. This fact is confirmed by data in this report itself.

Finally, the Mogridge hypothesis brashly contradicts a far more substantial base of widely documented data and understanding incorporated in Modal Choice Models for traffic Planning Analysis. These models consistently find that factors other than travel time are significant in the modal choice between rail and automobile. One such factor is that wait and walk time (out-of-vehicle time) is generally perceived by the traveler as 2 to 15 times more important than an equal amount of in-vehicle-travel-time. Thus, for example, a 60 minute trip by car could be perceived by the traveler as preferable to a 20 minute travel time by public transit which includes ten minutes of wait and transfer time

No valid empirical or theoretical basis for the Mogridge hypothesis has been shown. It is a highly speculative and dubious theoretical hypothesis. It directly contradicts a much stronger basis of experience and analysis in Modal Choice Modeling. As will be seen, all subsequent results of the report rest on this dubious foundation. In the opinion of this critic, there is no valid basis for the assumption of travel-time equality between roads and rail.

Trip-time Analysis

Any attempt to explain or critique this report should be introduced with the caveat that it is extraordinarily ambiguous in almost very detail needed to do an accurate assessment or critique or to replicate the results. Therefore, the best that can be done in most cases is to reverse engineer the results and infer what probably was done. Inevitably, this process will lead to some misinterpretations of the author's intention. If so, such misinterpretations would not have occurred had the author adequately and consistently documented his procedures in the first place.

We will first provide a qualitative overview of the "HLB" analysis then return to the quantitative details. The Austin region is broken down into seven "segments", each corresponding to a proposed light rail corridor, and varying in length from 2 to 16 miles. In order to streamline further discussion those seven segments will be designated by a numerical "Case" index as follows

Case	Line	Segment	From	To
1	Green	1	McNiel	CBD
2	Green	2	Slaughter	CBD
3	Red	1	Leander	McNiel
4	Red	2	McNiel	Lamar and Airport
5	Red	3	CBD	Lamar and Airport
6	Orange	1	CBD	5th and Pleasant Valley
7	Orange	2	ABIA	5th and Pleasant V alley.

The analysis assumes two parametric functional forms, claimed, with parameters appropriate to each segment, to represent the "door-to-door" trip-time over the length of the segment, by automobile, as a function of travel "volume", under two different conditions:

1) "without rail" and
2) "with rail".

These two trip-time functions have been designated Ta1 and Ta2, but the convention, as to which is which changes from one to the other in the middle of page 20; so, to avoid ambiguity we will distinguish them here with the self-defining terms or subscripts "with" and "without" transit

Those two functional forms are:

$$T_{without} = T_{ff} * (1 + A(V)^B) \quad (1)$$

$$T_{with} = (T_c - T_{ff}) / (1 + e^{-(D+E\,V)}) + T_{ff} \quad (2)$$

where

$T_{without}$ and T_{with} ="door-to-door" segment trip-time by auto; units unspecified but inferred to be minutes.

T_{ff} = "auto trip-time at free-flow speed"

A,B,D,E are as yet undetermined parameters, to be determined for each corridor.

V = "person auto trip volume in corridor"

The units of volume are nowhere specified in the report, but one is led to guess from the correspondence with Table 2 and following that they represent a corridor cross-section AADT somehow (unspecified) averaged over the length of the segment, expressed in vehicles per day. There is no rationale given for the form of the curves although both may be recognized as commonly used in somewhat different roles in transportation modeling.

The "without" function is closely related to the well known Bureau of Public Roads relation, for the trip-time, T, over a single section of road, at a point in time (not all day):

$$T = T_{ff}\left(1 + 0.015\left(\frac{V}{C}\right)^4\right)$$

where T_{ff} is free-flow trip-time

V is Volume, Vehicles per hour

C is capacity, vehicles per hour at 13% reduction of free-flow speed.

In the present application, however, the relation is used with V meaning *Daily* Corridor traffic or ADT, and the capacity, C, is an undefined quantity for a heterogeneous roadways system such as a corridor. It is not to be expected that the same relationship would hold for the essentially homogeneous case of data over one hour as for the highly variable case of data over a day. Nevertheless, with the constants A and B to be determined empirically, this may not be an unreasonable parametric model for the corridor trip-time to volume relationship. The TTI urban congestion data may be shown to correspond to such a relationship with the exponent B = 1, that is linear, and volume being defined as the regional total volume, vehicle-miles per day.

The "with rail" function is a different matter. This is given as

$$T_{with} = (T_c - T_{ff}) / (1 + e^{-(D+E\,V)}) + T_{ff}$$

Here T_{ff} is the free flow trip-time by car and

T_c is the "trip-time by the high capacity rail"

D and E are parameters to be determined for each particular segment.

This functional form is called a logistic equation and is commonly used in modal choice modeling, an entirely different role. There is no rationale given, nor, in my view, possible for this particular form of function *other than* the unstated fact that with suitable choice of parameters, it corresponds to the author's preconception of the way the function $T_{with}(V)$ *should* look, assuming the validity of the Mogridge hypothesis. In particular, for positive E, at high volume, T_{with} approaches the transit travel-time, T_c, exactly as hypothsized by Mogridge. This assumption is crucial to all the benefit estimates that follow.

Fitting the Parameters.

The methodology for estimating the model parameters, A, B, D, E is described as follows (p.19).

> "The estimation consists of quantifying the delay savings and the related travel costs reduction resulting from trip diversion from cars to the light rail system. To do so, trip- time and volume data were collected from Capital Area Metropolitan Planning Organization (CAMPO) and LRT ridership forecast were provided by Parsons-Brinkerhoff. - - HLB estimated the model"

That's all that was said of the crucial process of deriving the fit parameters. There is no other description of the exact nature, and amount of data, or geographic scope, or time-nature, collection hours, days, seasons, and years. The CAMPO and PB data were not given. There was no mention whatsoever of the process of choosing between alternative data selection and weighting which may significantly affect the outcomes. There is no description of the regression process itself, or of regression diagnostics that would provide some essential feeling for the significance of the fits. In other words, there is no way of determining the *significance* of the fit functions other than blind faith in the analyst.

Model Estimation Results

The results in part 4, provide specific parameter values for A, B, D and E, which along with T_c and T_{ff}, fully define the T(V) functions for each segment, for both "without" and "with" conditions. The parameter estimations are said to be valid over each part of each piece comprising the segment and from present to 2025, but are seen to be radically different from segment to adjacent segment. Table 1 below, summarizes these parameters as given on pages 20, 25, and 31, in the original report and some of the derivative findings.

Lines 4-10 are the stated segment and model fit parameters.

Lines 11 and 12 are the free-flow speeds inferred from the times and segment lengths for the auto (T_{ff}) and rail (T_c) cases for each segment. Note the remarkable range of variability for the rail times, T_c. The maximum speeds, Tc = 22.5 mph for Case 1, are unbelievable for what are purported to be average speeds, door-to-door, for light rail.

	Table 1	Estimated Model Parameters							
		Case:	1	2	3	4	5	6	7
			Green	Green	Red	Red	Red	Orange	Orange
	Segment	Units Inferred	McNiel-CBD	Slaughter-CBD	Leander-McNiel	McNiel-Lamarr	LaMarr-CBD	CBD-5th	5th-ABIA
	CASE PARAMETERS:								
4	**Segment Length**	**mi**	15	7.72	16	12	5.1	2	8.6
5	**Tff**	**min**	18	12	30	25	25	3	20
6	**Tc**	**min**	40	28	55	55	55	55	55
7	**A**		7.03E-07	8.71E-13	758160	2.172E-26	1.694	0.236	4.909E-10
8	**B**		1.263	2.239	-1.41	4.965	13.443	-0.448	2.037
9	**D**		-4.629	-3.969	0.2578	-19.149	64.835	-2.689	-6.7499
10	**E**		6.53E-05	0.0000202	-4.2E-05	0.00015	0.00031	6.936E-06	0.00023
11	**Speed(Tff)**	**mph**	50.0	38.6	32	30	12.2	40.0	25.8
12	**Speed(Tc)**	**mph**	22.5	16.5	17	14	5.6	2.2	9.4
13	**Stated Time without**	**min**	53.04	38.38	34	33	31.52	6.47	22.63
14	**Stated Time With**	**min**	44.23	36.81	32	29	26.46	6.86	24.85
15	**Stated Time Savings**	**min**	8.81	1.57	2	4	5.06	**0.39**	**2.22**
16	**V(Twithout)**	**veh/day**	126,000	346,030	59,352	117,900	0.80	0.030	13,722
17	**V(Twith)**	**veh/day**	X	X	59,510	115,259	X	23,869	21,403

Lines 13 and 14 give the stated door-to-door times for auto travelers for the "without" and "with" conditions.

Line 14 is the stated time saving "with rail". Note that in cases 6 and 7 the stated trip-times (page 32) "with" are greater than those "without" rail; yet the time difference is still (erroneously) stated as a time *saving* for rail.

With the Case parameters as given for each case and given the independent variable, V, one should be able to evaluate the two prototype functions, equations (1) and (2) above to find the segment door-to-door trip-time by auto with and without rail, as given in lines 13, and 14 above. However, in another glaring omission, the report does not reveal the segment volume, V, or the methodology for defining it for the various cases. Frustrated in that check, one should be able to reverse-engineer the issue, finding the value of V which, substituted into the appropriate equation would give the trip-time values on lines 13 and 14. These values of V are tabulated in lines 16 and 17 above. If everything checks, for each case, this would give the same values of V in line 16 and 17 and the difference in the functions evaluated at this common V would be the stated time saving per line 15.

In Case 1, Twithout is stated as 53.04 minutes and by equation (1) this corresponds to a Volume, V(Twithout) of 126,000 vehicles per day. For Twith, = 44.23 minutes, however, there is no solution. As can readily be confirmed by inspection of equation 2, or by the plots given here later, if the constant E, is positive, as it is in Case 1, then the maximum value of Twith is Tc, here 40 minutes. The X in line 17 denotes that there is no solution in this case and the stated value of case parameters and Twith are inconsistent at any value of V.

The same thing is true in case 2. Twith = 36.81 seconds is greater than the maximum possible value of equation 2 (28, minutes) and these Case parameters, are inconsistent with the stated value of Twith for any value of Volume.

Case 3 yields essentially consistent values of about V = 59,380 vpd for both without and with conditions.

Case 4 also yields consistent values of V for the two cases, at about V = 116,000 vpd.

Case 5 gives only an absurd solution for V(Twithout), (0.8 vpd) and no solution for V(Twith) because there is no value of V as *low* as stated 26.46 seconds.

Case 6 yields solutions for the two conditions, but they are vastly different among themselves. While the V(Twith) gives a reasonable value of V = 23,869, V(Twithout) gives an absurd result of 0.03 vpd. The reason for this will shortly be seen when we study the equation plots.

Case 7 again yields solutions for each condition but they are mutually inconsistent, V(Twithout) = 13,722 vpd while V(Twith) = 21,403.

In other words, for five out of the seven cases, the stated trip-times, Twith and Twithout are inconsistent with the stated Case parameters.

Trip-Time Plots

Further important insight is provided by plots of the trip-time functions (1) and (2) for each pf the various stated Case parameter sets and conditions, something HLB evidently did not do. These are presented in Figures 1 through 7, corresponding respectively to Cases 1 through 7.

Figures 1, 4, and 7 are what might be considered the nominal shape of the auto trip-times implied by the (faulted) Mogridge hypothesis. Without rail, auto trip-time increases monatonically, without limit with increasing volume. With rail, it is supposed, under Mogridge, to level off at a trip-time equal to that of the rail system. It is to be reemphasized that this result is not derived, and does not in any sense prove Mogridge, rather it is true by assumption inherent in the form of the assumed trip-time function, equation (2) above.

In Figure 2 the times for the two conditions, with and without are very closely similar, essentially identical for Volumes less than 250,000. Eventually they part but only beyond about 400,000 vpd, well beyond the range of interest.

Figure 3 (case 3) reveals an absurd behavior in which trip-times, both without and with rail, *decrease* with increasing volume. This arises from negative values of B and E.

Figure 5 is remarkable in that over most of the range of Volume, the stated case parameters give Twithout trip-times larger than the age of the universe, about 10 billion-billion-billion minutes! This is undoubtedly due to a typographical error but a critical one that should have been detected by a reasonable degree of self-check.

Figure 6 shows an inverted relationship, auto trip-times with rail significantly *larger* than without, an impossible condition in reality, and a clear indication of erroneous Case parameters.

The ensemble of plots strikes one with the astonishing disparity of shape of the T(V) functions provided by these estimated case parameter sets. The Case parameters are purportedly valid representations for each 2 or 3 mile "piece" of a segment, and for the "Club" of road users over a somehow (unexplained) expanded corridor. They are also claimed valid for year 2007 and 2025 projections. In other words, they are claimed robust over a remarkably broad scope. Yet, the immediately next abutting segment may display a radically different, if not diametrically opposite, functional form (e.g. negative slopes of time-delay vs volume).

Altogether, these wildly divergent functional forms raise serious questions about the case parameter estimations process. They are suggestive of use of badly inappropriate models, and/or inadequate and inconsistent estimation database. They suggest prediction far beyond the valid range of the estimation data set. Unfortunately, the report provides no description of the database, and *none* of the usual regression diagnostics, such as r-squared, t-tests of significance of the parameter estimates, prediction error estimates. or condition tests of the normal matrix which would alert one to these problems. By regression one can fit a straight line to any parabola. That does not mean the parabola is a straight line nor that the predictions past the data range are of any significance.

Altogether, these disparate results and omissions typify and suggest naïve use of a dangerously powerful regression tool to produce meaningless results. Moreover, these meaningless time-saving results are the foundation of all the ensuing results. There seems no need to go further.

Summary of Critical Errors and Deficiencies

- Basing the entire analysis on the controversial and largely discredited "Mogridge" hypothesis, which holds that in heavy congestion road travel speeds will tend to be controlled by and equal to mass transit travel time, contradicting the vast body of knowledge of modal choice determinants and traffic behavior. No valid theoretical or empirical proof is offered or referenced.
- Missing, careless, and inconsistent definition and use of units.
- Careless typographical errors in critical equations.
- Careless and changing definitions of critical terms.
- Failure to plot and review reasonableness of the segment trip-time functions – patently absurd functional forms.
- Concluding a travel-time *saving* with transit of 23 seconds when stated Twithout was actually less that Twith (Case 6). Fundamentally, this is a careless mistake, but it may well be indicative of an even more serious tendency to make, or overlook mistakes so long as they give the "right" answer.
- Failure to document critical aspects of the analysis in sufficient detail to support independent critical review and confirmation of results including
    - Details of the regression database

- Regression diagnostics
- Definition and derivation of segment "Volume", the independent variable in equations 1 and 2
- Methodology for "Club Benefits" and "Spillover Benefits" estimation.

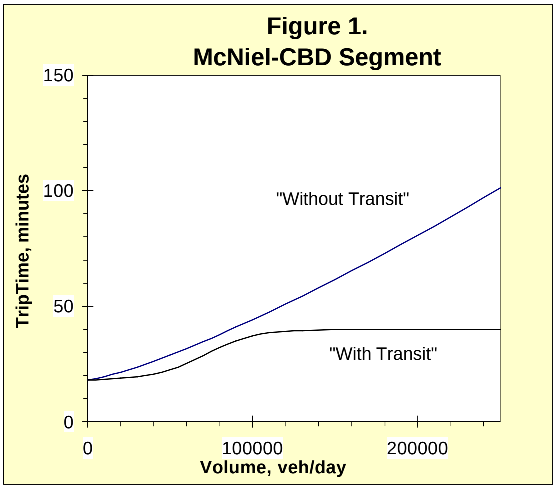
- Critical underlying time-savings estimates invalidated by internal inconsistencies between the stated case parameters and trip-time results on five of the seven analysis segments.

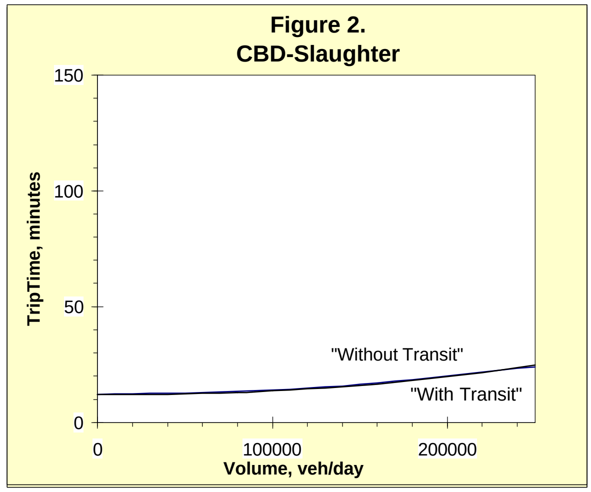
Summary Conclusion

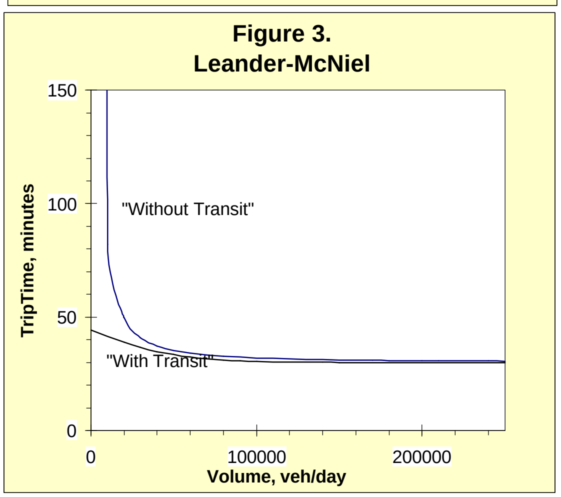
In view of the astonishing number and severity of problems reported herein, in the opinion of this critic the report is a travesty of honest,competent, scientific analysis and should be retracted by the sponsor.

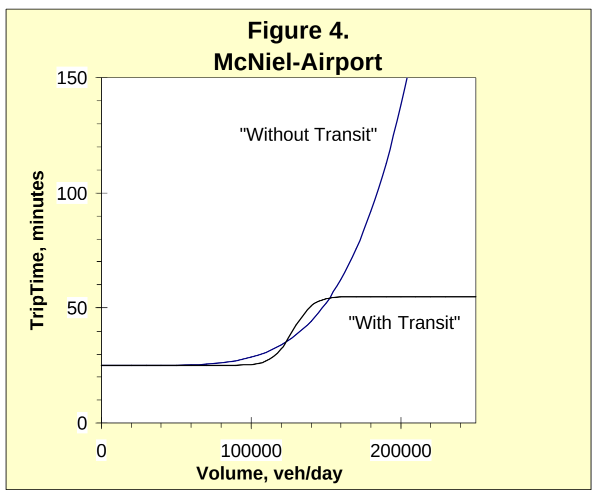
Figures 1-4. Trip-Time versus Volume Plots, Cases 1-4

Plots of equations 1 and 2 using the stated estimated case parameters.









Figures 5-7. Trip-time versus Volume Plots Cases 5-7